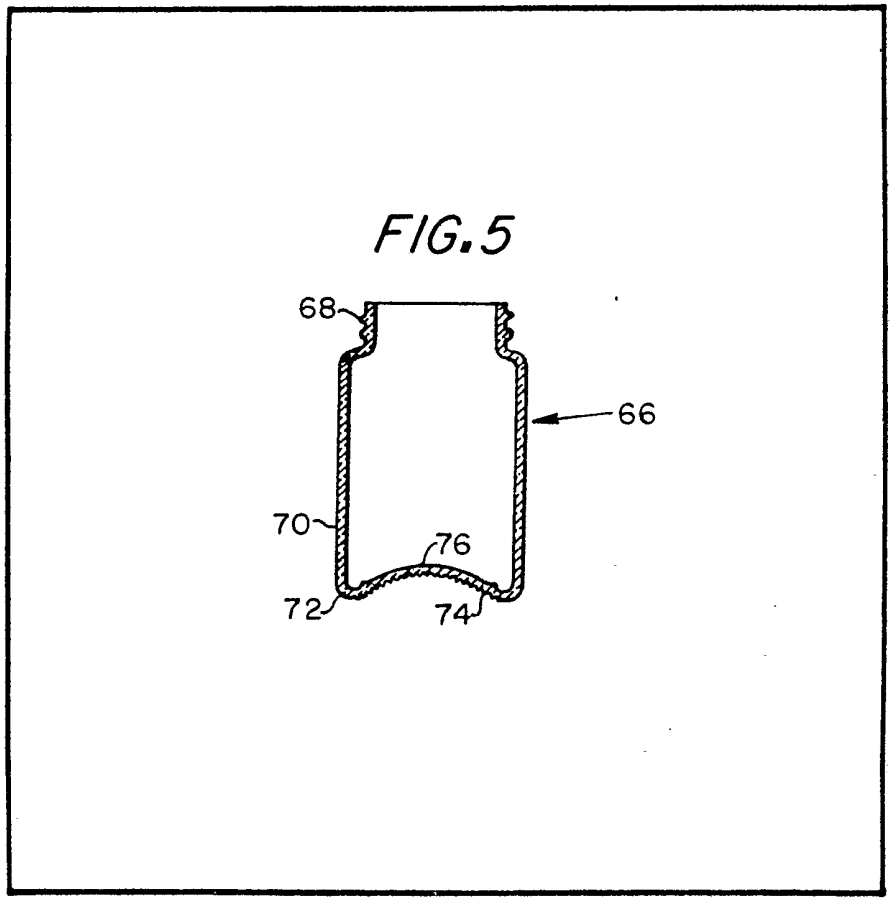
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GB 1237402
EP A1 0029639
US 1690035
US 0019964
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H5H
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(54) Glass containers suitable for microwave heating

(57) A glass container (66) suitable for microwave heating has an annular sidewall (70), a bearing surface (72), and a bottom (76) raised to form an upwardly-extending, arcuate center portion. Preferably, the container is a jar of capacity of between 177 cc. and 946 cc., and has a ratio between the diameter of and the maximum lift at the center portion of between 5:1 and 12:1. The bottom of the container may be knurled or stippled, and may be provided with a formation (74) to facilitate stacking.



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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FIG. 1

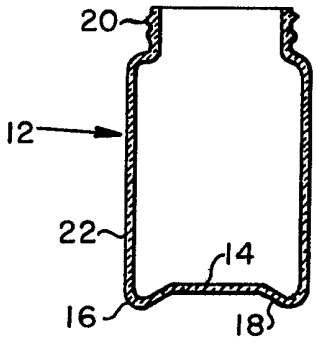


FIG. 2

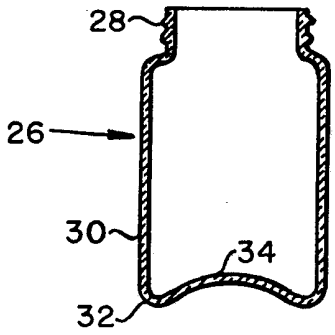


FIG. 3

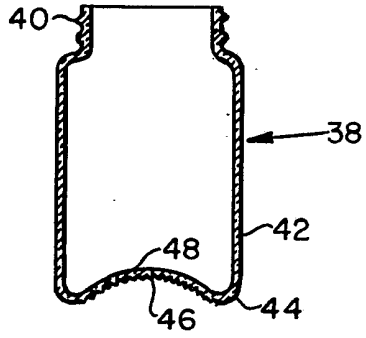


FIG. 4

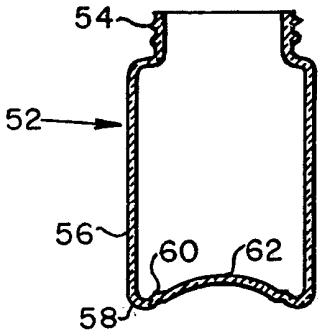
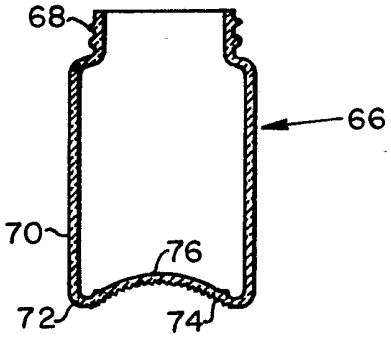


FIG. 5



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FIG. 6A

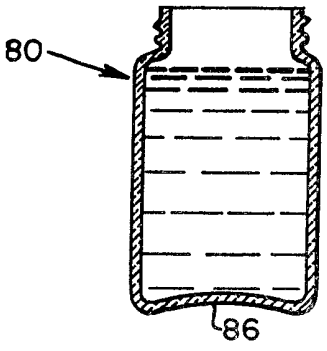


FIG. 6B

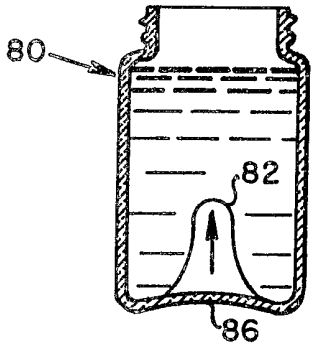


FIG. 6C

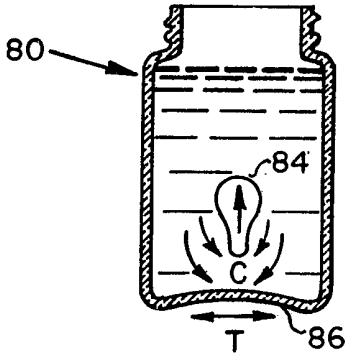
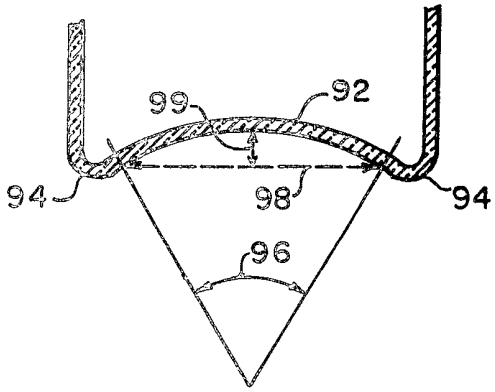


FIG. 7



SPECIFICATION

Improved microwavable glass container

This invention relates to glass containers particularly those suitable for heating in a microwave oven. It more particularly relates to jars utilized for commercial sale of food which may be heated in a microwave oven while in the jar.

It has been known in the glass art that the raising of a bottom portion and the thickening thereof are means of providing a stronger container to resist internal pressures. Typical of such containers are those used for champage and other naturally or artificially carbonated beverages. The use of a raised bottom portion was also known from very old bottle-making techniques such as shown in U.S. Patent 19,964 to Borden and U.S. Patent 1,690,035 to O'Neill. Such jars were of heavy construction and were manufactured before the existence of microwave ovens.

Now the jars, for the selling of food products such as spaghetti sauce and baked beans, generally are formed with as thin a wall as possible to reduce weight and also the cost of the jar. The jars also are formed in high speed moulding machines which need a relatively simple design for quick release and easy forming. The bottom design of the present commercial jar utilizes a raised flat portion in the center of the bottom, generally connected to the lower edges or bearing surfaces by generally straight portions extending from the raised flattened portion. The commercial jars have been found very satisfactory for shipping of food products such as spaghetti sauces and baked beans but when utilized in microwave ovens there are a certain number of the jars which crack upon heating. The problem with cracking is particularly prevalent in jars that have been subjected to extensive handling which may weaken their bottom surfaces. While the failure rate of such jars when heated in a microwave oven is not high, the percentages probably being less than a tenth of a percent, it nevertheless is a relatively large absolute number considering the millions of jars which are sold. Therefore, there is a need for a jar which is capable of being heated in a microwave without failure even if it has been subjected to handling which have caused scratches or surface defects. As is well known in the glass industry, scratches or other surface damage generally weaken the glass and lead to higher failure rate than the failure rate for a new jar with undamaged bottom surface. Nevertheless, there is also the need to maintain light weight and ease of molding in any glass product designed for shipping, storage and microwave heating of food products.

Therefore, there remains a need for a lightweight jar that is capable of being shipped, handled and heated by microwave with a failure rate of less than about one in 100,000 jars.

According to the invention there is provided a glass container suitable for microwave heating, the container having generally annular sidewalls and a bottom joined to the sidewalls, said bottom having a raised generally arcuate center portion extending upwardly between said sidewalls and a bearing surface on the lower peripheral portion of said bottom.

Another aspect of the invention provides a method of heating comprising providing a container having an upwardly extending generally arcuate curved bottom, placing material to be heated into said container, placing said container in a microwave device and activating said device to heat said material.

In preferred forms the container is a jar of diameter between about two and about five inches (about 5 cm and about 13 cm) and contains between about six and about 32 fluid ounces (about 177 cc and about 946 cc). The jar further has a ratio between diameter and the maximum rise at the center portion of the bottom of between about 5:1 and about 12:1.

Glass containers embodying the invention have been found to have numerous advantages over containers of the prior art. The present containers provide greater protection than conventional jars to the jar bottom from cracks or damage caused by setting on things due to the greater rise at the center of the bottom. The containers of the invention also provide reliable containers for heating in microwave ovens. The containers of the invention further are easily released from moulds during manufacture and are suitable for high speed forming

A jar in accordance with the invention is provided with a bottom that has a generally continuous arcuate uplifted surface. The arc is most desirably an arc of a circle. The glass of the bottom uplifted surface is generally of the same thickness as that in previous lightweight commercial jars. Shown in Figure 1 is a prior art jar 12 shown in cross-section. The bottom of the jar is generally comprised of a flat, slightly uplifted portion 14, bearing surface 16 and sloped areas 18. The jar also has threaded top portion 20 and sidewalls 22.

Illustrated in Figure 2 is a jar in accordance with the invention. The jar 26 comprises a threaded neck portion 28, sidewalls 30 and a bottom portion which has bearing surface 32 and an arcuate uplifted portion 34.

In Figure 3 is illustrated another jar in accordance with the invention in which the jar 38 is similar to the jar of Figure 2 having neck portion 40, sidewalls 42, bearing surface 44 and uplifted portion 48. The jar has the entire bottom surface 48 and 44 knurled as shown at 46. Knurling is known to increase the strength of glass articles by making crack propagation more difficult. The knurling provides pyramidal shaped raised areas which upon abrasive or striking contact will break off without significantly decreasing the glass strength. It has been found that knurling improves bottom strength of

containers embodying the present invention. However, while there is some improvement in performance with the knurling, the prime cause of the improved strength is the raised bottom portion. Knurling provides better protection from abrasion than from striking blows.

Illustrated in Figure 4 is a bottle or jar 52 of the invention which also has a stacking feature 60. The jar comprises a neck portion with threads 54, sidewalls 56 and bearing surface 58. The stacking feature 60 allows the jars to be stacked with the stacking feature mating with the lid of a jar which is placed underneath it. The generally arcuate upraised bottom of the invention extends from the stacking feature 60. In Figure 5 is illustrated a jar 66 also having a stacking feature. The jar 66 is comprised of a threaded neck portion 68, sidewalls 70, bearing surface 72 leading up to stacking feature 74. The arcuate raised portion 76 forms the center portion of the bottom. The entire bottom is knurled in this instance. It is also possble to knurl only a portion of the bottom of a jar while maintaining the remainder with a smooth glass surface finish. For instance, knurling may only be performed at the areas such as the stacking feature and bearing surface where abrasion is more likely. However, it is also possible to knurl the upraised portion where any damage would be more likely to lead to failure during heating.

For a better understanding of the mechanism which is believed to cause failure during microwave heating, reference is had to Figures 6a, 6b and 6c. Failure by the mechanism illustrated is especially likely to occur with thick material such as spaghetti sauce or baked beans. This is illustrated with a prior art jar generally indicated as 80 in which a sauce is to be heated. The jar has a central bottom portion 86. Upon heating as in Figure 6B, a bubble 82 will begin to form and rise. This bubble may be air or steam. The forming bubble 82 becomes detached in Figure 6C as bubble 84. Upon becoming detached, the sauce rushes to impact the point C where the bubble has become detached and applies high force to point 86. This force has been known to lead to failure. This failure mechanism is generally called cavitation failure and it is more fully described in a paper by R. G. Shapiro and J. F. Bayne entitled "Microwave Heating of Glass Containers", published in Food Technology, February, 1982, papers 46—48.

The amount of pushup desirable in a particular bottle will vary depending on the material to be heated, thickness of the glass, size of the container, length of heating expected and whether knurling is present. Typically, an amount of uplift between an arcuate diameter to height of bottom rise ratio of 25:1 to about 3:1 is suitable. A preferred range is a ratio of diameter distance to lift height distance of between about 5:1 and about 12:1 for good strength during heating. The optimum ratio between diameter distance and lift height distance is between about 6:1 and about 9:1 for ease of moulding, and strength during heating and shipping. By the height distance or rise distance, it is meant the amount of rise measured from the highest point on the exterior of the bottom down to the plane joining the lower peripheral portions of the arcuate raised portion. Diameter is the distance across the bottom of the arcuate raised portion of the bottom.

Another way of stating the amount of rise is to state it in terms of the arc of the angle included by the generally arcuate upraised portion of the bottom. As illustrated in Figure 7, the arcuate portion 92 which extends up from bearing surfaces 94 is an arc of about 60°. Typical of arc angles of the invention are those between about 8° and about 135°. Particularly suitable for the invention are considered to be those between about 38° and 87° for the typical jar utilized in the food industry. The preferred arc of the bottom is between about 50° and about 75° for jars between about two and about six inches (about 5 cm and about 15 cm) as this gives a rise which is easy to mould and of greatly increased strength over the standard bottom. As illustrated in Figure 7, the angle 96 is about 60° and has a radius of about 1-3/4 inches (about 4.5 cm) for a bottle or jar about 2-1/2 inches (about 6.4 cm) in diameter.

As illustrated in Figure 7, the amount of bottom rise or height of the arcuate portion is indicated by dashed line 99. The diameter or arcuate diameter of the raised portion is indicated by dashed line 98.

Any type of knurling is suitable. Typical of knurlings are those set forth as a Recommended Standard by the Glass Packaging Institute in their drawings G.P.I.—K-1 and G.P.I.—K-2. The knurling is generally in the form of small pyramids between about .01 inch and about .05 inches (about .25 millimeters and about 1.3 millimeters) in height. A preferred knurling for the jars of the invention is a ball point or pyramidal knurl such as the pyramidal CK 170A with a depth between teeth of about .02 inches (about .55 mm) as this has been found to allow easy forming and a significant increase in strength over an unknurled container.

While the invention may be suitably used with jars or containers of any thickness, is believed to find its greatest advantage in thin-walled food jars in which there is a difficulty with bottom weakness as the bottom thickness is much less than in older designs or in bottles which are intended to withstand internal pressure. The invention generally is suitable for high speed production with glass sidewall thicknesses between about 50 and 150 thousandths inches (about 1 mm and about 3.8 mm). A particularly preferred thickness is between about 70 and 120 thousandths inches (about 1.8 mm and about 3.0 mm) for use with a container of about five inch (about 5 cm) diameter as this wall thickness provides a lightweight container which can benefit from the increased strength against cavitation destruction which is possible with the pushed-up or raised bottom of the invention. The bottom thickness for the preferred jars is between about 120 thousandths inches and about 180 thousandths

inches (about 3.0 mm and about 4.6 mm) with an average bottom thickness of about 150 thousandths of an inch.

The articles of the invention may be formed by any known glass forming technique. Typical of such techniques are what are referred to as the press and blow technique and the blow and blow technique. In the press and blow technique which is prefererd for jar formation a gob of glass is placed into a cavity, a plunger pushes the glass into a mould to form threads and a parison for transfer to another mould. In the second mould, the parison is blown to final shape. Knurling is performed by a knurl pattern on the mould into which the glass is blown. The articles of the invention are suitable for the high speed press and blow operation.

The containers of the invention may be any size desired for microwave heating. Further, the containers may be in forms other than the preferred jars for food products. Included are containers for use in the kitchen, containers for industrial heating of food products and other materials in a microwave heater, bottles, and pressure containers. Preferred jars for utilization in the invention are those containing between about six ounces and about 32 ounces (about 177 cc and about 946 cc) and having a diameter of between about two inches and about five inches (about 5 cm and about 13 cm). This size includes a large proportion of the spaghetti sauce and baked beans jars which are a major source of home microwave heating. These jars are made in the millions and a significant increase in their strength would provide increased safety and utility to these jars.

The following examples illustrate tests done to illustrate the greatly increased strength of the jars of the present invention when subjected to microwave heating while containing a thick material such as spaghetti sauce. Tests are performed with stressed jars as the failure rate by cavitation of unstressed jars is so low that thousands of jars would have to be tested to obtain meaningful results.

Example 1

All testing was done using a thin-wall 15 oz. (about 426 cc) jar of about a three inch (about 7.6 cm) diameter with either conventional push-ups of 0.160″ (.4 cm) and 0.180″ (.46 cm) or high push-ups of the invention of 0.290″ (.74 cm) and 0.305″ (.77 cm) with both groups being moulded in moulds having knurled and unknurled bottom plates. There was no lettering or logo on the bottom plates. All four of these bottom plates were designed with a stacking feature.

Each of the four groups were tested in the following three test conditions: 1. the entire bottom plate was abraded with 150 grit emery cloth, 2. the entire bottom plate was abraded with 60 grit emergy cloth, and 3. a severe impact bruise/check was made in the center bottom.

Thirty jars for each of these twelve different sets were filled with spaghetti sauce and heated for 5 minutes using the high oven setting for the conventional microwave oven to ensure that cavitation would occur. The normal heating time for a 15 oz. jar of spaghetti sauce is in a microwave about 3 minutes. Each jar was stirred after $1\frac{1}{2}$ minutes to ensure thorough heating of the sauce. A cap was loosely placed on each sample to prevent splattering during the test.

Results:

Test results indicate that the high push-up and to a lesser degree bottom knurl decreased the overall breakage level that results from cavitation on damaged ware. The results are summarized in Table I below. The convention push-ups are noted as control examples.

Table I

Type of bottom abrasion	*Unknurled bottoms push-ups* 0.160" (4.1 mm) (control)	0.305" (7.7 mm)	*Knurled bottoms push-ups* 0.180" (4.6 mm) (control)	0.290" (7.4 mm)
150 grit				
No. tested[1]	30	30	30	30
No. failures	2	0	0	0
Percent failure	6.7%	0%	0%	0%
60 grit				
No. tested[1]	30	30	30	30
No. failures	15	1	1	0
Percent failure	50%	3.3%	3.3%	0%
Center bottom bruise/checks[2]				
No. tested[1]	30	30	30	30
No. failures	24	7	24	7
Percent failure	80%	23.3%	80%	23.3%

Notes: [1]All tests (15 oz. (444 cc) jars) were done on the high setting and cooked for a 5 minute period using spaghetti sauce as the product. Each sample was stirred after $1\frac{1}{2}$ minutes of cooking time to ensure thorough heating of the sauce.
[2]Center bottom bruise/checks were made with a single impact using the Preston Impact Tester at approximately 26"/sec.

The center bottom bruise/check test data shows the high bottom push-up to be significant in reducing cavitation breakage. In both the knurled and unknurled groups, an 80% failure rate occurred with the standard push-ups compared to a 23% failure rate in both groups with a high push-up. Although this damage was severe, similar bruise/checks could occur as a rseult of severe abuse. This type of severe damage generally negates any protection afforded by knurling because the force of the impact damage usually will crush any existing knurl.

However, the results from the 60 grit abraded tests also indicate the strength of the jars in accordance with the invention. The knurled standard push-up bottoms had the same breakage rate of 3.3% as the unknurled high push-up set did, compared to a 50% failure rate on the unknurled standard push-up. There were no failures in the knurled high push-up jars set.

There were only two failures in the 150 grit abraded sets, both of which occurred in the unknurled standard push-up set.

Glass distribution was measured on many of the breakage samples, revealing similar thicknesses in all four of the sample designs. Annealing was the same for all four designs.

Example 2

The process and testing method of Example 1 was repeated using a second group of bottles divided into the same twelve groups. A further test was performed using a standard unknurled production 15 oz. (444 cc) jar. This differed from test jars in that the middle portion of the jar bottom had letters identifying the manufacturer of the jar. These raised letters in effect made the center thicker. An off-center impact test was performed on the production jars.

The result of the test series of Example 2 is set forth in Table II. The results also demonstrate and conform the Table I results showing the advantages of the raised bottom portion for jar strength in microwave heating.

Table II

Type of abrasion	Unknurled bottoms push-ups 4.1 mm (control)	Unknurled bottoms push-ups 7.7 mm	Knurled bottoms push-ups 4.6 mm (control)	Knurled bottoms push-ups 7.4 mm	(Control) production 3.8 mm push-up
150 grit					
No. tested	50	40	50	50	50
No. failures	2	1	1	0	8
% failures	4%	2.5%	2%	0%	16%
60 grit					
No. tested	50	40	50	50	50
No. failures	21	1	2	0	5
% failures	42%	2.5%	4%	0%	10%
Center bottom bruise/checks impacted center bottom					*On letters*
No. tested	50	40	50	50	20
No. failures	43	7	41	7	6
% failures	86%	16%	82%	14%	30%
Impacted off center					
No. tested	—		—		50
No. failures	—		—		29
% failures	—		—		58%

The invention has been described particularly in regard to glass jars. However, the invention also finds utility in cooking vessels, both for home and industry. Further, the invention finds utility in bottles and pressure vessels subjected to microwave heating and cavitation of thick foods. Also, while knurling is the preferred bottom treatment, a stipple finish also could be used.

Claims

1. A glass container suitable for microwave heating, the container having generally annular sidewalls and a bottom joined to the sidewalls, said bottom having a raised generally arcuate center portion extending upwardly between said sidewalls and a bearing surface on the lower peripheral portion of said bottom.

2. A container according to claim 1, wherein said center portion extends upward by an amount such that the ratio between the diameter of the arcuate center portion and the amount of the rise above the plane of the peripheral portions of said arcuate center portion is between about 25:1 and about 3:1.

3. A container according to claim 2, wherein the ratios are between 5:1 and 12:1.

4. A container according to claim 3, wherein said ratios are between 6:1 and 9:1.

5. A container according to any preceding claim, wherein the thickness of the sidewalls is between about 50 and 150 mil (0.127 and 0.38 cm) and said container holds between 6 and 32 fluid oz. (177 and 946 cc).

6. A container according to any preceding claim, wherein said sidewalls have a thickness of between 70 and 120 mil (0.18 and 0.30 cm), and the container has a diameter of about five inches (12.7 cm).

7. A container according to any one of claims 1 to 5, wherein the diameter thereof is between two and five inches (5.1 and 12.7 mm).

8. A container according to any preceding claim, wherein at least a portion of said bottom portion is knurled.

9. A container according to any preceding claim, wherein the included angle of the generally arcuate raised center portion is between 8° and 135°.

10. A container according to claim 9, wherein said arcuate center portion has an included angle of 38° and 87°.

11. A container according to claim 10, wherein the included angle of the generally arcuate center portion is between 50° and 75°.

12. A container according to any preceding claim, wherein the thickness of said bottom is between 120 mils and 180 mils (0.3 and 0.46 cms).

13. A method of heating comprising providing a container having an upwardly extending generally arcuate curved bottom, placing material to be heated into said container, placing said container in a microwave device and activating said device to heat said material.

14. A method according to claim 13, wherein the center portion of said bottom extends upward by an amount such that the ratio between the diameter of said upwardly extending arcuate portion and the amount of the rise above the plane of the peripheral of the arcuate portion is between 25:1 and 3:1.

15. A method according to claim 14 wherein the ratios are between 5:1 and 12:1.

16. A method according to claim 15, wherein the ratios are between 6:1 and 9:1.

17. A method according to claim 13, 14, 15 or 16, wherein the thickness of the sidewalls is between 150 and 120 thousandths of an inch (0.127 and 0.38 ccs) and the container has a capacity of between 6 oz. (177 cc) and 32 oz. (946 cc).

18. A method according to any one of claims 13 to 17, wherein said sidewalls have a thickness of between 70 and 120 mil (0.18 and 0.30 cm) inch, and the container has a diameter of about five inches (12.7 cms).

19. A method according to any one of claims 13 to 17, wherein said container has a diameter of between two and five inches, (5.1 and 12.7 cms).

20. A method according to any one of claims 13 to 19, wherein said bottom portion is knurled.

21. A method according to any one of claims 13 to 20, wherein the included angle of the generally arcuate center portion is between 8° and 135°.

22. A container according to claim 21, wherein said arcuate center portion has an included angle of between 38° and 87°.

23. A container according to claim 22, wherein the included angle of said generally arcuate center portion is between 50° and 75°.

24. A container according to any one of claims 13 to 23, wherein said bottom thickness is between 120 mils and 180 mils (0.3 and 0.46 cms).

25. A method of microwave heating of materials comprising providing a container having an upwardly extending generally arcuate curved bottom portion, placing material to be heated into said container, placing said container in microwave device and activating said microwave device to heat said material, wherein said container is a jar holding between 6 oz. and 32 oz. (177 and 946 cc), the ratio between the diameter of said arcuate curved bottom portion and the height of the highest portion of the bottom above the plane joining the peripheral portion of the arcuate bottom portion is between 6:1 and 9:1 and the wall thickness of the container is between 70 and 120 mil (0.18 and 0.30 ccs).

26. A method of microwave heating materials substantially as herein described with reference to the accompanying drawings.

27. A glass container suitable for microwave heating of its contents, such container being constructed and arranged substantially as herein described with reference to and as illustrated in Figures 2 to 5 and 7 of the accompanying drawings.

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